

THAT WHICH IS CLAIMED:

1. A power conversion apparatus comprising:  
a DC link comprising first and second DC busses and a reference bus;  
a DC generator circuit coupled to the DC link and operative to generate first  
and second DC voltages with respect to the reference bus on respective ones of the  
5 first and second DC busses; and

a precharge circuit coupled to the DC link and operative to charge a first  
capacitance between the first DC bus and the reference bus and to transfer charge  
from the charged first capacitance to a second capacitance between the second DC  
bus and the reference bus.

10

2. An apparatus according to Claim 1, wherein the DC generator circuit is  
operative to commence generation of the first and second DC voltages on the first and  
second DC busses after the precharge circuit precharges the first and second DC  
busses.

15

3. An apparatus according to Claim 1, wherein the precharge circuit  
comprises:

a precharge converter circuit operative to charge the first capacitance from an  
AC source and/or a DC source; and

20 a balancer circuit operative to transfer charge between the first and second  
capacitances.

25

4. An apparatus according to Claim 3, wherein the balancer circuit is  
operative to selectively couple the first and second DC busses to the reference bus via  
an inductor.

5. An apparatus according to Claim 4, wherein the balancer circuit  
comprises:

30 an inductor; and  
first and second switches operative to selectively couple respective ones of the  
first and second DC busses to the inductor.

6. An apparatus according to Claim 5, further comprising a third switch operative to couple and decouple the inductor to and from the reference bus.

7. An apparatus according to Claim 3, wherein the DC generator circuit  
5 and the balancer circuit include a common half-bridge circuit.

8. An apparatus according to Claim 7, wherein the common half-bridge circuit is configurable to operate as a rectifier circuit in a first mode of operation and as a balancer circuit in a second mode of operation.

10

9. An apparatus according to Claim 1, wherein the precharge circuit is operative to charge the first capacitance to increase a voltage between the first DC bus and the reference bus to a first voltage and to initiate charge transfer to the second capacitance after the voltage between the first DC bus and the reference bus reaches  
15 the first voltage.

10. An apparatus according to Claim 9, wherein the precharge circuit is further operative to terminate charge transfer to the second capacitance after a voltage between the second DC bus and the reference bus reaches a second voltage.

20

11. An apparatus according to Claim 10, wherein the DC generator circuit is operative to generate the first and second DC voltages on the first and second DC busses from an AC source, and wherein the second voltage is greater than a peak voltage of the AC source.

25

12. An apparatus according to Claim 10, wherein the precharge circuit is further operative to initiate charge transfer from the charged second capacitance to the first capacitance to further boost the voltage between the first DC bus and the reference bus.

30

13. An apparatus according to Claim 9, wherein the DC generator circuit is operative to commence generation of DC voltages on the first and second DC busses after the precharge circuit precharges the first and second capacitances.

14. An apparatus according to Claim 9, wherein the precharge circuit comprises:

a buck converter circuit operative to charge the first capacitance from an AC power source and/or a DC power source;

5 a balancer circuit operative to transfer charge between the first and second capacitances; and

10 a control circuit coupled to the buck converter circuit and to the balancer circuit, the control circuit operative to cause the buck converter circuit to charge the first capacitance to increase the voltage between the first DC bus and the reference bus to the first voltage and to cause the balancer circuit to transfer charge from the charged first capacitance to the second capacitance after the voltage between the first DC bus and the reference voltage reaches the first voltage.

15. An apparatus according to Claim 1, wherein the DC generator circuit comprises a boost converter circuit.

16. An apparatus according to Claim 1, wherein the DC generator circuit is operative to generate the first and second DC voltages on the first and second DC busses from an AC power source and/or a DC power source.

20

17. An apparatus according to Claim 1, wherein the precharge circuit is operative to charge the first capacitance from an AC power source and/or a DC power source.

25

18. An apparatus according to Claim 1, further comprising first and second storage capacitors coupled between respective ones of the first and second DC busses and the reference bus, and wherein the first and second capacitances comprise respective ones of the first and second storage capacitors.

30

19. A power conversion apparatus comprising:

a DC bus;

a buck converter circuit coupled to the DC bus and operative to charge a capacitance coupled to the DC bus; and

a boost converter circuit coupled to the DC bus and operative to commence generating a DC voltage on the DC bus from an AC source and/or a DC source after the precharge circuit precharges the DC bus.

5        20. A power conversion apparatus, comprising:  
          a DC link comprising first and second DC busses and a reference bus;  
          a boost converter circuit coupled to the DC link and operative to generate first and second DC voltages with respect to the reference bus on respective ones of the first and second DC busses from an AC source and/or a DC source; and  
10        a precharge circuit coupled to the DC link and operative to charge a first capacitance between the first DC bus and the reference bus and to transfer charge from the charged first capacitance to a second capacitance between the second DC bus and the reference bus.

15        21. An apparatus according to Claim 20, wherein the boost converter circuit is operative to commence generation of the first and second DC voltages on the first and second DC busses after the precharge circuit precharges the first and second DC busses.

20        22. An apparatus according to Claim 20, wherein the precharge circuit comprises:  
          a buck converter circuit operative to charge the first capacitance; and  
          a balancer circuit operative to transfer charge between the first and second capacitances.  
25        23. An apparatus according to Claim 22, wherein the boost converter circuit and the balancer circuit include a common half-bridge circuit.

30        24. An apparatus according to Claim 23, wherein the common half-bridge circuit is configurable to operate as a boost rectifier circuit in a first mode of operation and as a balancer circuit in a second mode of operation.

25. An uninterruptible power supply (UPS) comprising:  
          a DC link comprising first and second DC busses and a reference bus;

a DC generator circuit coupled to the DC link and operative to generate first and second DC voltages with respect to the reference bus on respective ones of the first and second DC busses from either or both of a first power source and a second power source; and

5           a precharge circuit coupled to the DC link and operative to charge a first capacitance between the first DC bus and the reference bus and to transfer charge from the charged first capacitance to a second capacitance between the second DC bus and the reference bus.

10           26.     A UPS according to Claim 25, wherein the DC generator circuit is operative to commence generation of the first and second DC voltages on the first and second DC busses after the precharge circuit precharges the first and second DC busses.

15           27.     A UPS according to Claim 25, wherein the precharge circuit comprises:

              a precharge converter circuit operative to charge the first capacitance from an AC source and/or a DC source; and

20           a balancer circuit operative to transfer charge between the first and second capacitances.

25           28.     A UPS according to Claim 27, wherein the DC generator circuit comprises a boost converter circuit and wherein the precharge converter circuit comprises a buck converter circuit.

29.     A UPS according to Claim 27, wherein the DC generator circuit and the balancer circuit include a common half-bridge circuit.

30           30.     A UPS according to Claim 29, wherein the common half-bridge circuit is configurable to operate as a rectifier circuit in a first mode of operation and as a balancer circuit in a second mode of operation.

31.     A UPS according to Claim 25, wherein precharge circuit is operative to charge the first capacitance to increase a voltage between the first DC bus and the

reference bus to a first voltage and to initiate charge transfer to the second capacitance after the voltage between the first DC bus and the reference bus reaches the first voltage.

5           32. A UPS according to Claim 31, wherein the precharge circuit is further operative to terminate charge transfer to the second capacitance after a voltage between the second DC bus and the reference bus reaches a second voltage.

10          33. A UPS according to Claim 32, wherein the DC generator circuit is operative to generate the first and second DC voltages on the first and second DC busses from an AC source, and wherein the second voltage is greater than a peak voltage of the AC source.

15          34. A UPS according to Claim 32, wherein the precharge circuit is further operative to initiate charge transfer from the charged second capacitance to the first capacitance to further boost the voltage between the first DC bus and the reference bus.

20          35. A UPS according to Claim 25, wherein the precharge circuit is operative to charge the first capacitance from the first power source and/or the second power source.

25          36. A UPS according to Claim 25, wherein the first power source comprises an AC power source and wherein the second power source comprises a DC power source.

37. A UPS according to Claim 36, wherein the DC power source comprises a battery.

30          38. A UPS according to Claim 25, further comprising first and second storage capacitors coupled between respective ones of the first and second DC busses and the reference bus, and wherein the first and second capacitances comprise respective ones of the first and second storage capacitors.

39. A UPS according to Claim 25, further comprising a DC/AC converter circuit coupled to the DC link and operative to generate an AC voltage from the first and second DC voltages.

5        40. A method of operating a power converter including a DC link comprising first and second DC busses and a reference bus and a DC generator circuit coupled to the DC link and operative to generate first and second DC voltages with respect to the reference bus on respective ones of the first and second DC busses, the method comprising:

10            charging a first capacitance between the first DC bus and the reference bus;  
                  transferring charge from the charged first capacitance to a second capacitance between the second DC bus and the reference bus to charge the second capacitance;  
                  and then  
                  generating the first and second DC voltages on the first and second DC busses

15            using the DC generator circuit.

41. A method according to Claim 40:  
                  wherein charging a first capacitance comprises charging the first capacitance using a buck converter circuit coupled to an AC source and/or a DC source; and  
20            wherein transferring charge comprises transferring charge using a balancer circuit.

42. A method according to Claim 41, wherein the DC generator circuit and the balancer circuit include a common half-bridge circuit.

25

43. A method according to Claim 42:  
                  wherein transferring charge transferring charge from the charged first capacitance to the second capacitance using a balancer circuit comprises transferring charge from the charged first capacitance using the common half-bridge circuit as a  
30            balancer circuit; and  
                  wherein generating the first and second DC voltages on the first and second DC busses using the DC generator circuit comprises generating the first and second DC voltages on the first and second DC busses using the common half-bridge circuit as a rectifier circuit.

44. A method according to Claim 40:  
wherein charging the first capacitance comprises charging the first capacitance  
to increase a voltage between the first DC bus and the reference bus to a first voltage;  
5 and  
wherein transferring charge from the charged first capacitance to a second  
capacitance between the second DC bus and the reference bus to charge the second  
capacitance comprises initiating charge transfer from the charged first capacitance to  
the second capacitance after the voltage between the first DC bus and the reference  
10 bus reaches the first voltage.

45. A method according to Claim 44, further comprising terminating  
charge transfer from the first capacitance to the second capacitance after a voltage  
between the second DC bus and the reference bus reaches a second voltage.

15  
46. A method according to Claim 45, wherein generating the first and  
second DC voltages on the first and second DC busses using the DC generator circuit  
comprises generating the first and second DC voltages on the first and second DC  
busses from an AC source, and wherein the second voltage is greater than a peak  
20 voltage of the AC source.

47. A method according to Claim 46, wherein generating the first and  
second DC voltages on the first and second DC busses using the DC generator circuit  
is preceded by transferring charge from the charged second capacitance to the first  
25 capacitance to further boost the voltage between the first DC bus and the reference  
bus.